FINAL PROJECT REPORT

Impact of poultry litter application on yield and quality of alfalfa grown in Mississippi

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Abstract

Introduction

Demand for high quality forages has increased in the southeastern U.S. due to the desire to increase livestock productivity and grazing efficiency. Alfalfa (*Medicago sativa* L.) is an ideal species that can be inserted into traditional haying and grazing systems to enhance forage quality. Furthermore, in an era of high-priced protein and energy supplements, the higher quality of alfalfa and alfalfa-grass mixtures is of significant value to the beef and dairy industry, along with other forage-based livestock producers.

In Mississippi, a coordinated research and demonstration/extension effort has substantially increased alfalfa acreage 700% since 2014. As some of the targeted producers in the region have a negative view of alfalfa and its management challenges, many of these efforts have been under a pretext of demonstrating cutting and fertility management techniques. Within the program, discussion about the benefits of alfalfa production and use are integrated. This results in participants realizing that alfalfa has a potential as a forage crop because of the combination of new varieties, better nutrient management techniques, and marketing opportunities for the region.

Alfalfa requires high phosphorus (P) and potassium (K) soil fertility and has a high demand for these nutrients. Alfalfa removes large amounts of nitrogen (N) and K from the field when harvested as hay, and also has the ability to draw down nitrate levels within its root zone, thus

decreasing nutrient runoff and leaching potential. Manure, particularly poultry litter, is high in P and K and micronutrients such as boron. Proper applications of poultry litter to alfalfa can provide sufficient quantities of required nutrients without overloading the soil profile. Poorly timed applications, however, can physically damage plants, increase weed competition, and can result in excess soil N, potentially increasing N losses to water and the atmosphere (Lory 2015).

Poultry production was the top agricultural commodity in Mississippi for 2016, grossing nearly $2.3 billion in sales and ranking 5th in the nation (DAFVM, 2016). Poultry has been the leading commodity in Mississippi for 20 straight years, in which 28,000 employees were paid another $2.1 billion in wages and salaries (Mississippi Poultry Association, 2014). Poultry litter, a mixture of manure, feathers, and bedding material, is a valuable source of plant nutrients and organic matter that is of great interest to many livestock and row crop farm managers across Mississippi and remains the most sustainable option for disposal (Tabler et al., 2015). The use of poultry litter has shown to increase dry matter yields in bermudagrass production (Evers 2008), lint in cotton, and grain in corn (Mitchell and Tu 2003). For forages, linking dry matter production with litter utilization can be a difficult, yet effective approach for addressing both the problems associated with manure disposal, and impact reductions on the environment (Pant et al., 2004). In 2014, 210 broiler farms (10% of Mississippi total) were sampled to determine average nutrient contents of litter. Concentrations averaged 61.37, 47.44, and 69.39 lb/ton for K_2O, N, and P_2O_5, respectively (Tabler et al., 2015). Often times, poultry litter is the most economical, and most available source of fertilizer in Mississippi.

As alfalfa acreage across Mississippi and the Deep South increases, information regarding fertility management in this crop will be crucial in helping new farmers produce an economically sustainable forage. This projects seeks to bridge this knowledge gap by evaluating the impacts of poultry litter on alfalfa production in Mississippi. To address these needs, the following objectives were established: 1) Determine the impact of poultry litter fertilization on forage yield, plant persistence, forage quality, and economic analysis of alfalfa in Mississippi, and 2) Implement an Extension and Outreach program to educate beef cattle producers and small and medium-sized dairies about the use of alfalfa in their production systems with a sustainable poultry litter nutrient management program.

Materials and Methods

<u>Objective 1</u>: Determine the impact of poultry litter fertilization on forage yield, plant persistence, forage quality, yield components, and economic analysis of alfalfa in Mississippi.

The experiment was conducted at two locations in Mississippi during the 2017/2018 growing season (Coastal Plain Branch Experiment Station in Newton and H.H. Leveck Animal Research Farm in Starkville). The experiment, a randomized complete block design with four replications, was planted in the fall of 2017. Plots measured 5 ft x 12 ft. Three varieties were evaluated: 'Bulldog 505,' 'Bulldog 805,' and 'AlfaGraze 600RR'. Varieties were planted at a rate of 20 lb pure live seed (PLS) per acre in a prepared seed bed. A split-plot arrangement of the experimental treatments was used. The main plots were variety and the subplots were poultry litter application rates. Alfalfa was harvested at 30% bloom. Five harvests were conducted prior to the critical fall rest period.

Poultry litter was applied at a rate of 1/2X, and 1X in split applications (in the winter after seedlings

are greater than 4 inches, and after second cut) to achieve 100 lb K_2O applied per year (1/2X rate is approximately 1 ton/acre). Litter was analyzed by the Mississippi State Chemical Laboratory to determine nutrient content of litter used. Due to the N content of poultry litter, a positive control treatment in which synthetic N, P_2O_5, and K_2O was applied in the same amounts as poultry litter plots. A negative control treatment received P_2O_5 and K_2O, but no N. This resulted in a 3 x 4 factorial arrangement of treatments (3 varieties x 4 fertility treatments). Plots were limed prior to planting according to soil test recommendations. Chemical control of pests (weeds and insects) were applied when necessary.

Alfalfa yield was determined by harvesting the whole plot. A wet sample was collected from each plot for moisture determination and subsequent mineral and forage quality analysis. Samples were dried at 130^o F for at least 72 hours to determine dry matter concentration. Dried samples were ground to pass a 1 mm screen and analyzed using near-infrared spectroscopy (NIRS). Samples were analyzed using the alfalfa hay equation developed by the NIRS Forage and Feed Testing Consortium (Hillsboro, WI) to determine crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), fat, lignin, and mineral concentrations. Total digestible nutrients (TDN) and relative forage value (RFV) were calculated based on analyses. Stand density was rated at each harvest by counting the number of plants within a 3 ft^2 quadrat placed at a random location within each plot. All data was analyzed using the PROC GLIMMIX of SAS (SAS Inst., 2016). Replication within location was considered a random effect while variety, fertilizer treatment, and interaction between the effects were considered as fixed. Statistical significance was declared at $\alpha = 0.05$ unless otherwise stated. Data collected during the duration of Objective 1 was used to develop budget and economic models to determine the economic efficacy of poultry litter application in alfalfa production. Cost of production was determined based on estimated costs, yield, and quality data collected from field trials (Mississippi State Forage Planning Budgets, 2017).

<u>Objective 2</u>: Implement an Extension and Outreach program to educate beef cattle producers and small and medium-sized dairies about the use of alfalfa in their production systems.

A field day was hosted at the Coastal Plain Branch Experiment Station in Newton, MS, and at the H.H. Leveck Animal Research Unit on the campus of Mississippi State University in the spring and summer of 2018. At each event, seminars and a field tour were presented on the use of alfalfa in forage production systems in Mississippi. Topics that were covered included variety selection, fertility management, disease and pest management, harvest/grazing management, and economics/marketing. The field tour encompassed stops at several plot trials, including the poultry litter trial described above. Other stops included an alfalfa inter-seeded hay demonstration, an alfalfa grazing trial, and a potassium fertility trial already in progress. These events were open to the general public, and were highly advertised to livestock and hay producers within Mississippi, Louisiana, and Alabama. Natural resource professionals, private industry, and county Extension personnel were also in attendance. As part of the training at each event, Agriculture and Natural Resource County Agents from the Mississippi State Cooperative Extension Service will qualify for 5 hours of in-service training. At the end of each event, participants filled out surveys based on their knowledge gained, along with their likelihood of adoption of the practices discussed and displayed during the event.

Results and Discussion

Objective 1 Results

Field trials were established on October 4 and 6, 2017 at Newton and Starkville, MS, respectively (**Figures 1 and 2**). Initial fertilizer treatments were applied on November 27, 2017 at both sites. Due to heavy rains and poor drainage, combined with heavy weed infestations, the Starkville site was abandoned in the spring of 2018 with no harvests conducted. For Newton, excellent establishment and weed control was accomplished. A total of six harvests were conducted in Newton during 2018 growing season (April 25, May 30, Jul 2, Jul 30, Sep 4, and Oct 5), and five harvests in 2018 (Mar 18, May 6, Jun 3, Jul 9, and Aug 12).

Cumulative DM yield was analyzed using PROC GLIMMIX in SAS to determine the effects of year, harvest, variety, and fertilizer treatment on cumulative DM yield (**Table 1**). Year was found to be significant ($P < 0.0001$), therefore yield was analyzed as a repeated measure within year. The effect of harvest was also significant ($P < 0.0001$), and was therefore removed for continued analysis. No differences were observed by variety ($P = 0.3729$; **Table 1**) or fertilizer treatment ($P = 0.1141$; **Table 1**) for cumulative DM yield.

Forage nutritive value was measured for each plot at each harvest. Samples were dried, ground, and analyzed using NIRS to determine CP, ADF, NDF, fat, lignin, and mineral concentrations. Total digestible nutrients and RFV were calculated based on these results. Only CP, ADF, NDF, TDN, and RFV will be discussed. Similar to DM yield, quality parameters were run in SAS as a repeated measure due to repeated harvests. For CP, no differences were observed for variety ($P = 0.7118$) or fertilizer treatment ($P = 0.4470$). Mean CP values were above 20% for all harvests. For ADF, significant differences were observed for variety ($P = 0.0029$). For several harvests, 'Bulldog 505' had significantly lower ADF than the other two varieties. Similar to ADF, differences were observed by variety ($P = 0.0071$) for NDF. Both conventional varieties had lower NDF concentrations than 'AlfaGraze 600RR' in several harvests. Finally, for TDN, differences were observed by variety ($P < 0.0001$; **Figure 3**) and fertilizer treatment ($P = 0.0452$; **Figure 4**).

Objective 2 Results

Two field days were hosted during the 2018 growing season. These included the Coastal Plain Forage Field Day on April 5 in Newton (**Figure 5**) and the MSU Forage Field Day on July 17 in Starkville, MS. These meetings were attended by producers, industry representatives, and public sectors (MSU Extension, USDA-NRCS, and Soil and Water Conservation Districts). A total of 39 were in attendance in Newton, followed by 23 in Starkville. Survey analysis for each field day can be found in **Tables 3** and **4**. In Newton, 62% or attendees reported agriculture as their primary occupation, with a majority of producers citing hay as their main agricultural business. Attendees were very positive on the information presented at the field day, with 100% of the responses saying that the content was relevant to their needs. In Starkville, agriculture was again the primary occupation of the attendees (41%), with 45% of their business described as other (i.e. timber, row crop, etc.). Similar to the Newton field day, 100% of the attendees described the event as relevant to their needs. The transfer of information was apparent in the responses to content, as few producers were familiar with the management practices discussed (25%). For both events, 51%

of attendants said they would tell others about what they learned. This is extremely important, as most producers rely on information gained from neighbors regarding the implementation of specific practices into their operations. The positive response observed from each field day indicates that there is a strong interest in the use of alfalfa as a perennial hay crop in Mississippi, and that more research and training events are necessary to increase the skills required for increased production.

Results from the field trials were presented at the field days, along with regional and national meetings. Below are citations from all events and presentations in which NAFA supported.

Rushing, J.B. 2019. Alfalfa Checkoff: Alfalfa in the South. Progressive Forage Magazine. April. (popular press).

Rushing, J.B. 2019. Hay production in Mississippi. SunSouth Hay Day. Newton, MS. 5, Jun. (presentation).

Rushing, J.B. 2019. Impact of poultry litter application on alfalfa yield and quality grown in Mississippi. American Forage and Grassland Council Annual Conference. St. Louis, MO. 6-9, Jan. (abstract/poster).

Rushing, J.B. 2018. Cool-season Forage Options. Jasper County Cattlemen's Association. Bay Springs, MS. 15, Oct. (presentation)

Rushing, J.B. 2018. Alfalfa production and research. CP Fall Forage Field Day. Coastal Plain Branch Experiment Station, Newton, MS. 27, Sep. (presentation)

Rushing, J.B. 2018. Cool-season Forage Options. Hinds County Cattlemen's Association. Raymond, MS. 18, Oct. (presentation).

Rushing, J.B. 2018. Alfalfa production and research. Starkville Forage Field Day. South Farm. Mississippi State, MS. 17, Jul. (presentation).

Rushing, J.B. 2018. Grazing Management and Forage Production. Kemper County Cattlemen's Association. DeKalb, MS. 19, Jun. (presentation).

Lemus, R., J.B. Rushing, and J.A. White. 2018. Influence of harvest management and potassium fertilization in alfalfa production. North American Alfalfa Improvement Conference. Logan, UT. 4-6, Jun. (abstract).

Maples, J.G., J.B. Rushing, R.W. Lemus, and J.C. Lyles. 2018. Economic analysis of the application of poultry litter on alfalfa production in Mississippi. Southern Extension Economics Committee Annual Meeting. Myrtle Beach, SC. 11-13, Jun. (selected poster).

Rushing, J.B., R. Lemus, and J.C. Lyles. 2018. Impact of poultry litter application on yield and quality of alfalfa grown in Mississippi. 72nd Southern Pasture and Forage Crop Improvement Conference. Fayetteville, AR. 14-16, May. (abstract/poster).

Rushing, J.B. 2018. Current Research at CPBES. Coastal Plain Forage Production Field Day. Newton, MS. 5, Apr. (presentation).

Rushing, J.B. 2018. How to establish legumes in southern pastures and forage systems. Alabama Farmer's Federation Commodity Organization Meeting – Hay and Forage. Montgomery, AL. 8, Feb. (invited presentation).

Conclusion

This project is part of an on-going effort to generate essential data while simultaneously educating producers, government agencies, and the private industry on the potential of alfalfa production in Mississippi. Based on results from the 2018 and 2019 growing seasons, 'Bulldog 505' has the potential to generate high DM yields with lower costs, compared to the other varieties tested. Costs and soil test analysis should be the primary factors in determining a nutrient management plan for alfalfa production. In terms of forage nutritive value, alfalfa can produce much higher quality feedstuffs than traditional hay species in the Deep South. Crude protein values above 20%, and TDN values of well over 50% are much better than traditional high quality bermudagrass hays. Based on producer response, more information regarding management and variety selection (especially long term data) is needed to increase producer acceptance and market adoption. Continued efforts, in terms of field trials and fertility management, will enable forage specialists to more accurately base recommendations. Also, soils data could evaluated to more thoroughly determine the effects of poultry litter application on nutrient build-up and removal.

Acknowledgements

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Evers, G.W. 2008. Comparison of broiler poultry litter and commercial fertilizer for coastal bermudagrass production in the Southeastern US. Journal of Sustainable Agriculture. 12(4):55-77.

Lory, J.A. 2015. Manure application to alfalfa. Animal Manure Management: eXtension. Http://www.articles.extension.org/pages.8931/manure-application-to-alfalfa.

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Parman, B. 2017. Forage Planning Budgets. Mississippi State Extension Service. Mississippi State, MS, 39762. Publication 3030.

Tabler, T., A. Brown, G. Hagood, M. Farnell, C. McDaniel, and J. Kilgore. 2015. Nutrient content in Mississippi Broiler Litter. Mississippi State Cooperative Extension Service. Publication 2878.

USDA-NASS. 2018. United States Department of Agriculture National Agricultural Statistics Service. Alfalfa and hay production reports. Accessed Sep 14, 2018.

Table 1. Mean cumulative dry matter yield (lb/acre) by variety and fertility treatment, 2018-2019, Coastal Plain Branch Experiment Station, Newton, MS.

Variable	Yield (lb/acre)	
	2018	***2019***
Variety		
Bulldog 505	11,188	7,418
Bulldog 805	9,820	8,084
AlfaGraze 600RR	10,519	6,602
Treatment		
(1) 1 ton PL/acre*	10,856	8,641
(2) 2 ton PL/acre*	10,754	7,448
(3) Synthetic N, P, K*†	10,569	6,229
(4) Synthetic P, K*†	9,857	7,155

*Applied in split applications; ½ in winter 2017 and ½ approximately 30 d prior to first harvest.
†Synthetic fertilizers were applied as 33-0-0 for N, 0-46-0 for P, and 0-0-60 for K; amounts used were based on PL analysis and were applied at the same rate as treatment 2.

Table 2. Mean cost per ton ($/ton) by variety and fertilizer treatments, 2018-2019, Coastal Plain Branch Experiment Station, Newton, MS.

Variable	Cost per ton ($/ton)§	
	2018	***2019***
Variety		
Bulldog 505	96.29 c*	147.57 b
Bulldog 805	112.49 b	147.96 b
AlfaGraze 600RR	126.18 a	198.87 a
Treatment		
(1) 1 ton PL/acre†	93.89 b	115.37 b
(2) 2 ton PL/acre†	99.18 b	143.45 b
(3) Synthetic N, P, K†‡	128.71 a	209.34 a
(4) Synthetic P, K†‡	124.84 a	191.03 a

*Lowercase letters denote significant differences within a year by variable ($\alpha = 0.05$).
†Applied in split applications; ½ in winter 2017 and ½ approximately 30 d prior to first harvest.
‡Synthetic fertilizers were applied as 33-0-0 for N, 0-46-0 for P, and 0-0-60 for K; amounts used were based on PL analysis and were applied at the same rate as treatment 2.
§Costs include operational/input expenses on a per acre basis for baleage. These include: equipment, seed, pesticide, fertilizer, net wrap, plastic wrap, labor, and depreciation costs (Mississippi State University Forage Planning Budget, 2017).

Table 3. Survey data from the Coastal Plain Forage Field Day held on April 5, 2018, in Newton, MS (39 attendees).

Question	**Response**			
Counties/states represented	9 counties in MS; 4 states (MS, LA, AR, AL)			
Is agriculture primary occupation?	*Yes*		*No*	
	62%		37%	
How many years have you been in business?	*0-10*	*11-20*	*21-30*	*>31*
	20%	16%	6%	43%
What is your primary ag business?	*Stocker*	*Cow/calf*	*Hay*	*Other*
	10%	34%	36%	16%
	Agree		*Strongly Agree*	
Instructors were knowledgeable of subject matter.	25%		75%	
The content was relevant to my needs.	0%		100%	
The content was at an understandable level.	51%		48%	
The content was well-organized.	34%		62%	
The content was based on credible information.	27%		72%	
Attending program was worth my time.	20%		79%	
I would recommend this program to others.	31%		68%	
I increased my knowledge of the topics covered.	34%		62%	
I learned new skills related to topics covered.	20%		51%	
I will use information I learned in this program.	44%		55%	
I will tell others about what I learned.	48%		51%	
	None	*Little*	*Some*	*A lot*
How much of content did you already know?	0%	6%	58%	24%
How many of the resource materials will you use?	0%	6%	51%	27%
How well did information meet your expectations?	0%	0%	41%	48%

Table 4. Survey data from the MSU Forage Field Day held on July 17, 2018, in Starkville, MS (23 attendees).

Question	**Response**			
Counties/states represented	11 counties in MS			
Is agriculture primary occupation?	*Yes*		*No*	
	41%		58%	
How many years have you been in business?	*0-10*	*11-20*	*21-30*	*>31*
	26%	0%	0%	26%
What is your primary ag business?	*Stocker*	*Cow/calf*	*Hay*	*Other*
	5%	30%	20%	45%
	Agree		*Strongly Agree*	
Instructors were knowledgeable of subject matter.	9%		91%	
The content was relevant to my needs.	0%		100%	
The content was at an understandable level.	50%		50%	
The content was well-organized.	20%		80%	
The content was based on credible information.	28%		72%	
Attending program was worth my time.	20%		80%	
I would recommend this program to others.	20%		80%	
I increased my knowledge of the topics covered.	33%		66%	
I learned new skills related to topics covered.	33%		66%	
I will use information I learned in this program.	25%		75%	
I will tell others about what I learned.	48%		51%	
	None	*Little*	*Some*	*A lot*
How much of content did you already know?	0%	25%	50%	25%
How many of the resource materials will you use?	0%	0%	50%	50%
How well did information meet your expectations?	0%	0%	22%	77%

Figure 1. Alfalfa poultry litter field trial taken on November 10, 2017 at the Newton location.

Figure 2. Alfalfa poultry litter field trial taken on April 4, 2018 at Newton location.

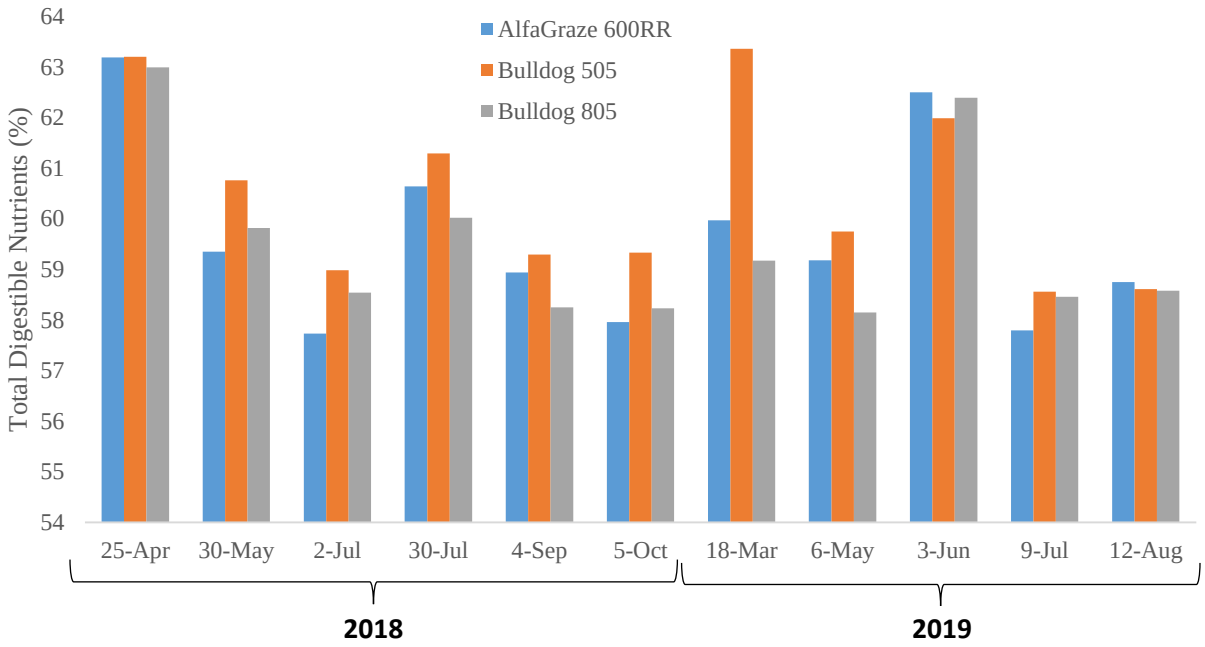

Figure 3. Mean total digestible nutrients (TDN) by variety across all fertilizer treatments, 2018-2019, Coastal Plain Branch Experiment Station, Newton, MS.

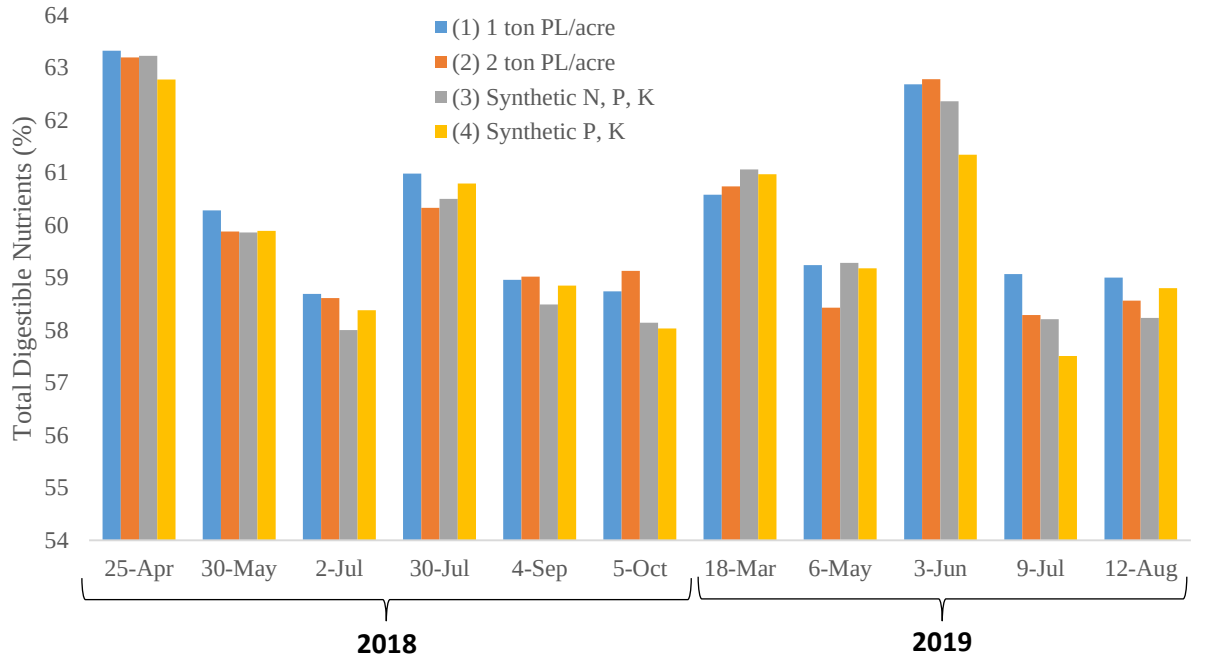

Figure 4. Mean total digestible nutrients (TDN) by fertilizer treatment across all varieties, 2018-2019, Coastal Plain Branch Experiment Station, Newton, MS.

Figure 5. Coastal Plain Forage Field Day hosted on April 5, 2018.